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Recreational Trampling Experiments: Effects of Trampler Weight and Shoe Type

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Abstract—A standard protocol for conducting experimental trampling studies was developed by Cole and Bayfield (1993). Two variables that were not standardized in that protocol are the type of shoe worn by tramplers and the weight of tramplers. In a study conducted in four different vegetation types, tramplers wearing lug-soled boots caused significantly more immediate vegetation cover loss than tramplers wearing running shoes. Shoe type had no significant effect on cover loss 1 year after trampling or on vegetation height. Heavier tramplers caused a significantly greater reduction in vegetation height than lighter tramplers, both immediately after trampling and 1 year later. Trampler weight had no significant effect on vegetation cover loss. This suggests that it is important to standardize shoe type and trampler weight in trampling experiments.

Keywords: experimental methods, recreation, vegetation

Our understanding of the effects of recreational trampling on natural vegetation has been advanced greatly by the application of experimental research designs. Such studies have particularly improved our understanding of the relationship between trampling intensity and vegetation response and the relative vulnerability of different plant species, growth forms, and plant communities. For this latter purpose it would be helpful to be able to compare the response of species, growth forms, and communities included in different studies. The comparability of different studies is highly suspect, however, because each study has typically used a unique set of experimental procedures.

A recent paper appealed for greater standardization of experimental trampling studies and detailed a standard protocol developed over several years of trial and discussion in the United States and the United Kingdom (Cole and Bayfield 1993). Application of that standard protocol in a variety of different ecoregions and vegetation types has already produced more general insights into vegetational response to trampling (Cole 1993).

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In the discussion of standard trampling treatments, Cole and Bayfield (1993) stated that their standard treatment used walkers of moderate weight (75 ± 10 kg), wearing boots with lug soles. However, it was not clear whether a standard weight and shoe type was important. This paper presents the results of experiments that assess vegetational response to trampling by walkers of different weights and wearing different shoe types. These results can be used to improve the standardization of trampling experiments.

Study Areas

These trampling experiments were conducted in one vegetation type in each of four mountainous regions in the U.S.A. The four vegetation types, named for the most abundant ground cover species, were (1) *Valeriana sitchensis*, lush subalpine herb meadows in the Cascade Mountains of Washington; (2) *Vaccinium scoparium*, subalpine coniferous forests with a dwarf-shrub ground cover in the Rocky Mountains of Colorado; (3) *Maianthemum canadensis*, low-elevation hardwood forests with a herbaceous ground cover in the White Mountains of New Hampshire; and (4) *Amphicarpa bracteata*, low-elevation cove hardwood forests with a herbaceous ground cover in the Great Smoky Mountains of North Carolina. More complete descriptions of these vegetation types can be found in Cole (1993).

Methods

Details on the layout of the experimental plots, trampling treatments, measurements, and data analysis can be found in Cole and Bayfield (1993). The study was arranged as two 4-by-4-by-2 factorial experiments. In both experiments, four trampling intensities—25, 75, 200, and 500 passes—were applied in each of the four vegetation types. Conditions were also monitored on control plots to evaluate changes over time that should not be attributed to the trampling treatments. In both experiments primary

interest was in the effects of the third factor—the weight and shoe type of the trampler. In the first experiment, the effect of shoe type was assessed by comparing the effects of a 77-kg trampler (±5 kg) wearing lug-soled boots to the effects of the same trampler wearing lightweight running shoes. In the second experiment, the effect of trampler weight was assessed by comparing the effects of tramplers who weighed 59 ± 5 kg to the effects of tramplers who weighed 77 ± 5 kg. For this second experiment, all tramplers wore boots with lug soles. Each experiment utilized a randomized block design, with four blocks.

The primary measures of vegetation response to trampling were relative vegetation cover and relative vegetation height. Both measures express conditions (vegetation cover and height) after trampling as a proportion of initial conditions, with a correction factor applied to account for changes on control plots. Both relative cover and relative height would be 100 percent in the absence of change caused by trampling. Therefore, lower relative cover and relative height values indicate greater amounts of vegetation loss and height reduction. Relative cover and relative height, immediately after trampling and 1 year after trampling, were calculated for each treatment. The significance of differences between shoe types and weights of the trampler was tested with analysis of variance. Where interactions between main factors were significant, simple effects were examined in more detail, using the least significant difference test. A significance level of 0.05 was used for both the analyses of variance and least significant difference tests.

Results

Shoe Type

As reported elsewhere (Cole 1993), relative vegetation cover after trampling varied significantly with number of passes and with vegetation type (table 1). The significant variation between blocks within the same vegetation type further emphasizes the variation in susceptibility that exists even at the microscale. Differences between shoe types were also significant, although mean squares were not as great as for number of passes or vegetation type. None of the interactions of other factors with shoe type were statistically significant. Mean relative cover after trampling was 31 percent when the trampler wore lug-soled boots and 37 percent when the trampler wore running shoes.

One year after trampling, relative vegetation cover varied significantly with number of passes, vegetation type, and block, but not with shoe type. The interaction between vegetation type and shoe type was significant. In two vegetation types, lug-soled boots caused more cover loss than running shoes; they caused less cover loss in the other two types. However, differences were not statistically significant in any individual vegetation type. Across all four vegetation types, mean relative cover 1 year after trampling was 68 percent when the trampler wore lug-soled boots and 67 percent when the trampler wore running shoes.

Relative vegetation height immediately after trampling and 1 year after trampling varied significantly with number of passes, vegetation type, and block. However, shoe type had no effect on vegetation height (table 2). Mean relative vegetation height immediately after trampling was 29 percent when the trampler wore lug-soled boots and 34 percent when the trampler wore running shoes. Mean relative height 1 year after trampling was 69 percent when the trampler wore lug-soled boots and 72 percent when the trampler wore running shoes.

Weight of the Trampler

Relative vegetation cover did not vary significantly with weight of the trampler, either immediately after trampling or 1 year after trampling (table 3). Immediately after trampling, the interaction between number

Table 1—Analysis of variance for the effect of number of passes, vegetation type, and shoe type on relative vegetation cover immediately after trampling and 1 year after trampling.

		Immediately after trampling		1 year after trampling	
Source of variation	df	Mean square	F	Mean square	F
Blocks	3	1,050	7.19**	5,013	15.28**
Number of passes	3	18,988	130.05**	11,033	33.64**
Vegetation type	3	7,186	49.22**	8,995	27.42**
Shoe type	1	1,249	8.55**	3	0.01
Passes x vegetation	9	532	3.64**	1,408	4.29**
Passes x shoe	3	138	0.95	237	0.72
Vegetation x shoe	3	333	2.28	929	2.83*
Passes x vegetation x shoe	9	81	0.55	384	1.17
Error	93	146		328	

Significance: * ≤ 0.05; ** ≤ 0.01.

Table 2—Analysis of variance for the effect of number of passes, vegetation type, and shoe type on relative vegetation height immediately after trampling and 1 year after trampling.

Source of variation	df	Immediately after trampling Mean square	F	1 year after trampling Mean square	F
Blocks	3	1,939	8.39**	3,973	8.49**
Number of passes	3	5,748	24.88**	12,404	26.50**
Vegetation type	3	19,333	83.69**	5,858	12.52**
Shoe type	1	571	2.47	172	0.37
Passes x vegetation	9	247	1.07	896	1.91
Passes x shoe	3	127	0.55	146	0.31
Vegetation x shoe	3	888	3.84*	1,440	3.08*
Passes x vegetation x shoe	9	448	1.94	210	0.45
Error	93	231		468	

Significance: * ≤ 0.05; ** ≤ 0.01.

Table 3—Analysis of variance for the effect of number of passes, vegetation type, and weight of trampler on relative vegetation cover immediately after trampling and 1 year after trampling.

Source of variation	df	Immediately after trampling Mean square	F	1 year after trampling Mean square	F
Blocks	3	673	8.96**	7,755	29.26**
Number of passes	3	16,948	225.55**	9,769	36.86**
Vegetation type	3	11,747	156.34**	8,780	33.13**
Weight of trampler	1	149	1.98	872	3.29
Passes x vegetation	9	388	5.16**	911	3.44**
Passes x weight	3	256	3.41*	451	1.70
Vegetation x weight	3	69	0.92	539	2.03
Passes x vegetation x weight	9	41	0.55	152	0.57
Error	93	75		265	

Significance: * ≤ 0.05; ** ≤ 0.01.

of passes and weight of the trampler was significant. At the lowest trampling intensity—25 passes—the heavier trampler caused significantly more vegetation loss than the lighter trampler. At all other trampling intensities, however, there was little difference between weights. Across all four trampling intensities, mean relative cover after trampling was 31 percent for the 77-kg trampler and 33 percent for the 59-kg trampler. One year after trampling, none of the interactions of other factors with weight of trampler were significant. Mean relative cover 1 year after trampling was 64 percent for the 77-kg trampler and 69 percent for the 57-kg trampler.

Relative vegetation height varied significantly with weight of the trampler, both immediately after trampling and 1 year after trampling (table 4). Immediately after trampling the interaction between vegetation type and weight of trampler was significant, although the mean square associated with the interaction was small compared to that of the weight factor. The heavier trampler caused significantly more height reduction than the lighter trampler in only two of the vegetation types—the two that were most resistant to height reduction following low trampling intensities. In the *Vaccinium scoparium* type, mean relative height was 58 percent with the 77-kg trampler and 75 percent with the 59-kg trampler. In the *Maianthemum canadensis* type, mean relative height was 12 percent with the 77-kg trampler and 32 percent with the 59-kg trampler. In the *Potentilla simplex* type, mean relative height was 9 percent with the 77-kg trampler and 11 percent with the 59-kg trampler. In the *Valeriana sitchensis* type, relative height was 19 percent with both the 77-kg and 59-kg trampler.

One year after trampling, none of the interactions of other factors with weight of trampler were statistically significant. The heavier trampler caused more height reduction than the lighter trampler in all four vegetation types. Across all four types, mean relative height was 61 percent with the 77-kg trampler and 79 percent with the 59-kg trampler.

Table 4—Analysis of variance for the effect of number of passes, vegetation type, and weight of trampler on relative vegetation height immediately after trampling and 1 year after trampling.

Source of variation	df	Immediately after trampling		1 year after trampling	
		Mean square	F	Mean square	F
Blocks	3	1,428	6.89**	3,042	6.09**
Number of passes	3	4,707	22.72**	11,320	22.64**
Vegetation type	3	20,567	99.25**	3,275	6.55**
Weight of tramper	1	3,211	15.30**	10,457	20.92**
Passes x vegetation	9	394	1.90	1,272	2.54*
Passes x weight	3	270	1.30	1,046	2.09
Vegetation x weight	3	815	3.93*	45	0.09
Passes x vegetation x weight	9	201	0.97	496	0.99
Error	93	207		500	

Significance: * ≤ 0.05; ** ≤ 0.01.

Discussion and Conclusions

This study corroborates the findings of earlier research that vegetation cover and height are greatly affected by trampling and that the magnitude of response is strongly influenced by trampling intensity (Liddle 1975). The magnitude of response is also strongly affected by vegetation durability. Different vegetation types respond differently, as do different blocks—even those located only a few meters away from each other. Although effects are less pronounced, the type of shoe worn by tramplers and the weight of tramplers can have modest effects on certain types of vegetation response.

The type of shoe worn had more of an effect on vegetation cover loss than on vegetation height reduction. It also had more of an effect immediately after trampling than 1 year later. The mean vegetation cover loss caused by trampling with lug-soled boots was 6 percent greater than that caused by trampling with running shoes in the four vegetation types examined. One year after trampling, vegetation cover loss was still evident but the magnitude of loss did not differ with shoe type.

The weight of the trampler had more of an effect on vegetation height reduction than on vegetation cover loss. It had more of an effect 1 year after trampling than immediately after trampling. Immediately after trampling, the 77-kg tramplers reduced vegetation height 9 percent more than lighter (59 kg) tramplers in the four vegetation types examined. One year after trampling, the height reduction caused by the heavier trampler was 18 percent more than that caused by the lighter trampler.

Experimental trampling studies such as those reported here can help managers plan for recreational use. Application of standard protocols for such studies will increase the comparability of results. In addition to the standard procedures recommended by Cole and Bayfield (1993), it is important to standardize shoe type and weight of the trampler. I recommend using tramplers of moderate weight (as close to 77 kg as possible) wearing boots with lug soles as the standard treatment. Lighter tramplers can carry packs to increase their weight to the standard.

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